Polyurethane

Polyurethane as a good thermal insulation material have been using since 1950s. The polyurethane filling sandwich panels are preferred by the investors and designers. The polyurethane having the best insulation values provides 40% saving in the heating and ventilation expenses. The usage of the fossil fuels establishes 80% of the carbon dioxide release in the world. The usage of polyurethane is very good approach for increasing CO_2 as the primary suspect of the global warming. The investors n the other hand expect the highest performance for the lowest investment costs, and polyurethane is the best reply.

Polyurethane is a plastic polymer established with the reaction of the isocyanides having NCO and poliol with OH group. The participation reaction is the polymerization reaction fully, and it is the immediate lower group of the plastic family. Polyurethane foam is obtained with the composition of the following four raw materials:

- Poliol
- Isocyanate
- n-Pentan-Blowing agent
- Catalyst

The ideal foam is formed having the closed cell structure, as a result of the chemical reaction of the activators in addition to two liquid fluid "isocyanate" and "poliol". The foam formation speeds are controlled by the catalysts. The proper formulation of two materials and the control of the foam reaction as well as the polyurethane are specified below:

- Density
- Mechanical Strength
- Closed Cell Structure
- Heat Resistance
- Solvent Resistance
- Reaction Speed
- Bond Strength

The chemical reactions are evaluated in four phases. At the first phase, poliol is combined with the isocyanides. In this phase, the fluid liquid will be formed immediately, and the foam will be commenced to form at the second phase. At the third phase; the foam mixture will be extended up to times of the dormer volume by forming the heat. In this phase, different materials are bonded firmly and continuously with the adhesive property of the foam. At the phase four, a resistant coating is formed at the external surface of the free foaming. If any liquid is left in this phase, the foam formation continues and the liquids find their way to close the gaps. However; the most homogenous foaming process is obtained with polyurethane homogenous sections.

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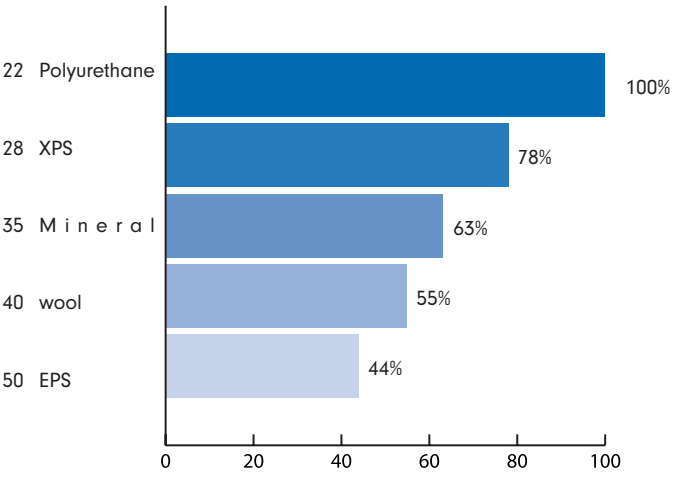
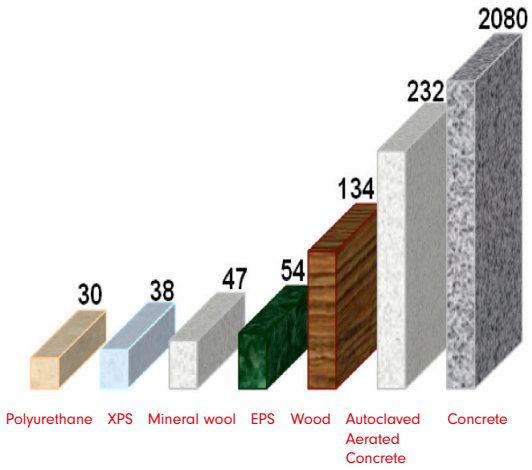
With the completion of the foam reactions, millions of small closed cells are formed. Each of the cells is filled with the blowing gas. The most important reason behind the excellent thermal insulation of the polyurethane foam is the in-cell gases having low thermal conductivity. Assan Panel uses n-Pentane gas as the blowing gas for polyurethane which does not present any harm to ozone.

Thicknesses of the different materials in case of identical heat insulation (mm)



The values are taken the standard TS 825.

Insulation capacity of polyurethane rigid foams (mm)



Polyurethane is an ideal filling material in the continuous line sandwich panel production due to such features. In addition; it is used in the discontinued lines and the structural gaps as the filling material.

The properties of the polyurethane change depending on the intensity of the material. The increase in the intensity will increase the bearing and drawing resistance. The polyurethane materials increased depending on the needs are produced in the various intensities from 30 to 100 kg/m^3. The polyurethane having the intensity of 40 kg/m^3 consists of polyurethane material in the quantity of 4.5% of the product only. The remaining 95.5% of the volume consists of the gases. The following three criteria are very important:

- Bonding to the metals firmly
- Best bearing capacity in roof and siding applications
- Best thermal insulation value

Also the production process and cell structure of the polyurethane affect the mechanic resistance properties in addition to the intensity. The bearing capacity of the sandwich panel system increases substantially due to the high sliding (shifting) resistance of the polyurethane as the filling material.

All solid, liquid and gas materials change depending on their dimensions. The structure extends with the increase in energy, as it is shrunk with the decreases in energy. The solid cell and the liquid gas in the polyurethane is no exception to this rule. Therefore, the head causes pressure and shrinking on the cell walls depending on its level. The thermal conductivity of the polyurethane also depends on the intensity of the material.

The closed cell system of the polyurethane insures non-permeability with capillary effect. It is only possible to leak water through diffusion effect depending on the application. The wet is affected from the temperature and relative humidity in the ambient. The polyurethane weight will be affected only 5% and %0.15 in volume at even 100% relative humidity. In this case, the metal surfaces of the sandwich panels form closed surfaces and decrease the practical importance of the humidity levels. The polyurethane material not allowing wet permeability will contribute the thermal insulation feature of the material considering the high thermal conductivity of water (0,60 W/mK).

The steam permeability is also very important for comfort in the structures. The steam diffusion resistance (μ) and the thickness subject to diffusion (Sd) are two important characteristic values. The steam diffusion resistance (μ) is exclusive for the materials and determined by comparing with the resistance of the air which is considered as 1. The steam permeability in sandwich panel systems depends on the intensity of the polyurethane, production process, and the type of the metal surface.

Water Vapor Diffusion Resistance	μ Values
Air	1
Wood	40
EPS	20-100
Mineral Wool	1
Polyurethane	30-100
PVC Membrane	10.000-80.000
Polyethylene Foil	100.000
Metals	∞

Countless of chemicals may contact with polyurethane in the construction site such as solvents, paints, welding materials, wood protective materials, and etc., and it has high resistance against them. In addition, it has high resistance against mineral oils, fume gases, aggressive industrial ambient conditions, acid and alkaline environments. Polyurethane also resistant against molding and decomposing, it does not lead bacteria and pesticides to grow.

Although the acoustic proofing feature of the polyurethanes having closed cell structure is less than the polyurethanes having open cell structure; it has the sound absorbing feature in normal industrial structures depending on the need of the structure. However, additional solutions may be required for sensitive regions and offices.

The Change of Acustic Conductivity Loss Against Frequency (dB)

Polyurethane Thickness		Frequency (Hz)																	
		125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000
50	mm	7,3	9,3	11,7	8,5	11,4	12,3	13,3	14,1	14,7	15,9	15,3	11,5	11,8	23,4	29,2	32,4	29,8	32,5	36,9
60	mm	8,1	22,1	14,2	14,5	13,0	13,9	13,8	14,6	15,3	16,0	15,3	13,0	18,3	24,2	29,2	32,5	29,8	32,5	36,9

The Change of Acustic Absorbtion Coefficient Against Frequency (dB)

Polyurethane Thickness		Frequency (Hz)										
		315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000
50	mm	0,08	0,11	0,22	0,20	0,05	0,59	0,09	0,11	0,04	0,07	0,18	0,07
60	mm	0,14	0,21	0,25	0,49	0,06	0,69	0,12	0,12	0,22	0,08	0,20	0,11

All tests are made by Istanbul Technical University-Mechanical Faculty.

Physical Properties of Polyurethane

Density	40 (± 2) kg/m^3
Thermal Conductivity (·)	max. 0,024 W/mK
Water Absorption (168 hours) (% volume)	2%
Reaction to Fire (EN 14509)	B.S2.d0
Closed cell percentage	95%
Vapour diffisuon resistance	30-100
Shear strength of core material (fcv)	min. 0,11 Mpa
Shear modulus of core material (G)	min. 2 MPa
Shear strength after long-term loading	t: 1.000 saat min. 35% t: 2.000 saat min. 30% t: 100.000 saat min. %7
(fcv-long-term)	t:1.000 hours min. 35% t:2.000 hours min. 30% t:100.000 hours min. 7%
Compression Strength	min. 0,095 MPa
Tensile Strength	min. 0,018 Mpa
Heat resistance (°C)	-200 / +110 °C
Dimensional Durability (EN 13165)	Level DS(TH) 11